

# PATENT SPECIFICATION

DRAWINGS ATTACHED

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855,459

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## COMPLETE SPECIFICATION

### Improvements in or relating to Electro-Surgical Apparatus

5 We, KEELER OPTICAL PRODUCTS LIMITED, a British Company, of 39, Wigmore Street, London, W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electro-surgical apparatus.

10 It is essential in certain fields of electro-surgery that the process of body tissue destruction, known as coagulation, be carefully controlled. At the present time it is customary for this to be monitored by an ammeter placed in the output of the diathermy equipment; or  
15 for the change of temperature to be measured at the point of reaction. Neither of these procedures affords an accurate indication of the actual structural changes that occur in the tissues. It is an object of the invention to provide means whereby coagulation can be accurately controlled.

According to the present invention there is provided an apparatus for controlling the  
25 coagulation of the tissues of a patient while being subjected to diathermy, wherein the electrical impedance change or changes involved in the operation are translated with a variable D.C. voltage which can be made  
30 to operate an electrical indicator and relay circuit the latter circuit incorporating means for switching off the diathermy at a predetermined level of coagulation of the said tissues.

It is known that normal biological tissues  
35 behave as a complex electrical network comprising resistance and capacitance in which the cells of the tissue form the capacitance and the ambient electrolytic solutions which join the cells form the resistance and the gradual  
40 destruction of the tissue will cause relative changes in the magnitude of both these parameters in accordance with the degree of destruction. The present invention makes use of

these effects to vary the effective magnification of a tuned electrical circuit of conventional form by coupling the tissues of the patient in a suitable manner to the external tuned circuit. In this way, variations of the electrical properties of the tissues will reflect themselves as a change in the external tuned circuit to which they are coupled and these effects are employed to operate a control device which will switch off the power applied to the tissues at any stage in the degradation of the tissues. By measuring the total Q or magnification factor of both diathermy and patient, circuit control can be exerted on the apparatus which obviates the necessity for the operator to assess action by the appearance visible to the naked eye which frequently is impossible. Providing the output circuit is at resonance, a voltage actuated control is applicable. If the diathermy circuit can be made to have a variable Q then the sensitivity of the control device is increased.

The apparatus comprises a radio frequency oscillator which supplies power at a frequency of the order of 1 to 2 megacycles per second through a high impedance circuit to the patient by means of a pair of leads one of which is earthed and attached to the body of the patient, the other being connected to a small metallic probe which is placed in contact with the tissue that is to be coagulated by the radio frequency currents that will flow through the patient. During the application of the probe, the impedance of the patient between the two electrodes first falls to an extent governed by the type of tissue operated upon and thereafter rises rapidly as coagulation sets in. If therefore a radio frequency rectifier volt-meter is connected across the leads to the patient, the voltage will rise rapidly as coagulation proceeds.

The accompanying drawing is a circuit diagram showing a radio frequency rectifier volt-

meter employed in carrying out the invention.

Referring to the drawing, the radio frequency rectifier volt-meter incorporates an input series-parallel network comprising a condenser 1 and resistances 2 and 3 which can be set to predetermined values according to the type of operation being performed. The output from the resistance 2 is connected to a radio frequency rectifier such as a thermionic diode 4 and the subsequent D.C. output is smoothed by a filter network consisting of condensers 5 and 6 and resistance 7 which may also be adjusted to predetermined values according to the nature of the operation. The D.C. output from the filter network is connected to a potentiometer 8 and the D.C. output is further amplified by a D.C. amplifier 9 to an extent capable of operating an electro-magnetic relay 10 the contacts of which are normally closed and are connected in series with a source of power producing the radio frequency energy for the apparatus. Thus when the voltage has risen to a predetermined level which can be set by the potentiometer 8, the relay contacts will be opened and the power supply to the patient will be cut off at the appropriate phase of the operation. The D.C. output from the rectifier 4 may also be applied simultaneously to an indicator device 11 such as a volt-meter, "magic-eye" or the like to assist pre-calibration and to enable the progress of coagulation to be observed so that the operation can be arrested by other means in the event of the amplifier ceasing to function. A radio frequency choke 12 is connected between the anode of the rectifier 4 and earth in order to prevent a reverse D.C. charge being applied back to the patient. The choke 12 must possess low D.C. resistance but its impedance must be large in comparison with the resistance 2. If desired the circuit may include an audible warning device (not shown) adapted to be brought into operation upon completion of the tissue change. The terminal circuitry can also be modified in a number of ways without departing from the scope of the invention.

The method of coagulation control afforded by the invention is applicable to the use of diathermy in ophthalmic surgery, neuro-surgery, general surgery and urological surgery. It is particularly useful in ophthalmic and neurological surgery where precise coagulation control is essential. This includes such operations as retinal detachment, thalamotomy and pallidotomy.

#### WHAT WE CLAIM IS:—

1. Apparatus for controlling the coagulation of the tissues of a patient while being subjected to diathermy wherein the electrical

impedance change or changes involved in the operation are translated with a variable D.C. voltage which can be caused to operate an electrical relay and indicator circuit, the latter circuit incorporating means for switching off the diathermy at a predetermined level of coagulation of the said tissues.

2. Apparatus as claimed in Claim 1, wherein a radio frequency rectifier volt-meter is connected across the electrodes of the diathermy apparatus.

3. Apparatus as claimed in Claim 2, wherein said radio-frequency rectifier volt-meter incorporates an input series-parallel network comprising a variable condenser and variable resistances which can be set to predetermined values, the output from one of said resistances being connected to a radio frequency rectifier, the subsequent D.C. output being smoothed by a filter network consisting of variable condensers and a resistance adjustable to predetermined values.

4. Apparatus as claimed in Claim 3, wherein the D.C. output from said filter network is connected to a potentiometer and is further amplified by a D.C. amplifier to an extent capable of operating an electro-magnetic relay the contacts whereof are normally closed and connected in series with a source of power producing the necessary radio frequency energy, the arrangement being such that when the voltage has risen to a predetermined level which can be determined by said potentiometer, said relay contacts will open and cause the power supply to be cut off.

5. Apparatus as claimed in any one of the preceding claims, wherein the output from the said rectifier is applied simultaneously to a visual indicator to assist pre-calibration and to permit the progress of coagulation to be observed.

6. Apparatus as claimed in any one of the preceding claims, wherein an audible warning device is provided and adapted to be brought into operation upon completion of the tissue change.

7. Apparatus as claimed in any one of the preceding claims, wherein said rectifier is a thermionic diode and a radio frequency choke is connected between the anode of said thermionic diode and earth to prevent a reverse D.C. change being applied back to the patient.

8. Electro-surgical apparatus substantially as hereinbefore described with reference to the accompanying drawing.

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## PROVISIONAL SPECIFICATION

## Improvements in or relating to Electro-Surgical Apparatus

We, KEELER OPTICAL PRODUCTS LIMITED, a British Company, of 39, Wigmore Street, London, W.1, do hereby declare this invention to be described in the following statement:—

This invention relates to electro-surgical apparatus.

It is essential in certain fields of electro-surgery that the process of body tissue destruction, known as coagulation, be carefully controlled. At the present time it is customary for this to be monitored by an ammeter placed in the output of the diathermy equipment; or for the change of temperature to be measured at the point of reaction. Neither of these procedures affords an accurate indication of the actual structural changes that occur in the tissues. It is an object of the invention to provide means whereby coagulation can be accurately controlled.

According to the present invention there is provided a method of controlling the coagulation of the tissues of a patient while being subjected to the influence of an oscillating electric current of high frequency, wherein the electrical constants of the tissues are employed to vary the resonant characteristics of a diathermy output circuit which is measured by an electrical indicator and relay circuit, the latter circuit incorporating means for switching off the diathermy at a predetermined level of coagulation of the said tissues.

It is known that normal biological tissues behave as a complex electrical network comprising resistance and capacitance in which the cells of the tissue form the capacitance and the ambient electrolytic solutions which join the cells form the resistance and the gradual destruction of the tissue will cause relative changes in the magnitude of both these parameters in accordance with the degree of destruction. The present invention makes use of these effects to vary the effective

magnification of a tuned electrical circuit of conventional form by coupling the tissues of the patient in a suitable manner to the external tuned circuit. In this way, variations of the electrical properties of the tissues will reflect themselves as a change in the external tuned circuit to which they are coupled and these effects are employed to operate a control device which will switch off the power applied to the tissues at any stage in the degradation of the tissues. By measuring the total Q or magnification factor of both diathermy and patient, circuit control can be exerted on the apparatus which obviates the necessity for the operator to assess action by the appearance visible to the naked eye which frequently is impossible. Providing the output circuit is at resonance, a voltage actuated control is applicable. If the diathermy circuit can be made to have a variable Q then the sensitivity of the control device is increased.

The method of coagulation control afforded by the invention is readily applicable to the use of diathermy in the following fields of electro-surgery, viz., ophthalmic surgery, neuro surgery, general surgery and urological surgery.

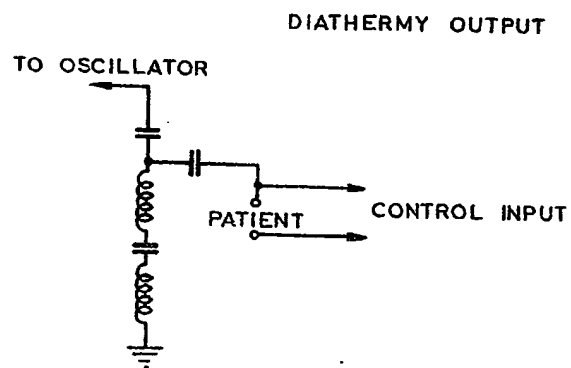
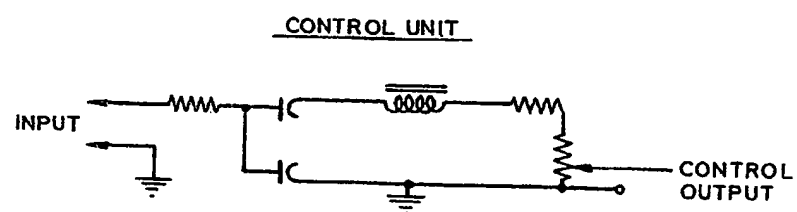
The control circuit can be made to perform the following functions viz: actuate an on/off relay for the main equipment and to effect such actuation at any desired degree of coagulation, operate a visual indicator showing the rate of tissue change and/or an audible warning device upon completion of such change.

In the accompanying drawings, Figures 1 and 2 illustrate examples of electrical circuits for the control unit and diathermy output respectively that may be employed in carrying out the invention.

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the Original on a reduced scale.*

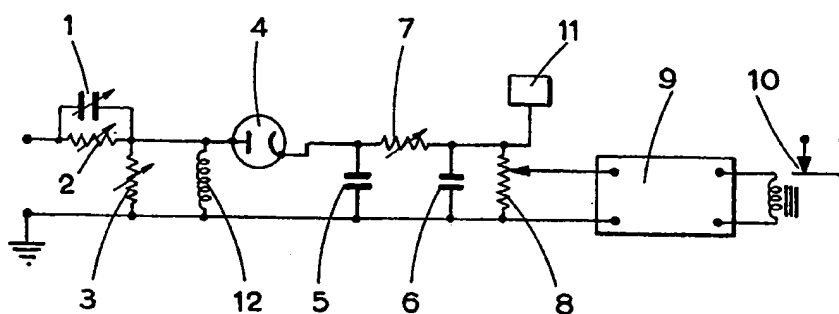


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COMPLETE SPECIFICATION

1 SHEET

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